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Applying the Ecosystem Approach to Select Priority Areas for Forest Landscape Restoration in the Yungas, Northwestern Argentina

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Abstract This paper proposes a method to select forest restoration priority areas consistently with the key principles of the Ecosystem Approach (EA) and the Forest Landscape Restoration (FLR) framework. The methodology is based on the principles shared by the two approaches: acting at ecosystem scale, involving stakeholders, and evaluating alternatives. It proposes the involvement of social actors which have a stake in forest management through multicriteria analysis sessions aimed at identifying the most suitable forest restoration intervention. The method was applied to a study area in the native forests of Northern Argentina (the Yungas). Stakeholders were asked to identify alternative restoration actions, i.e. potential areas implementing FLR. Ten alternative fincas—estates derived from the Spanish land tenure system—differing in relation to ownership, management, land use, land tenure, and size were evaluated. Twenty criteria were selected and classified into four groups: biophysical, social, economic and political. Finca Ledesma was the closest to the economic, social, environmental and political goals, according to the values and views of the actors involved in the decision. This study represented the first attempt to apply EA principles to forest restoration at landscape scale in the Yungas region. The benefits obtained by the application of the method were twofold: on one hand, researchers and local actors were forced to conceive the Yungas as a complex net of rights rather than as a sum of personal interests. On the other hand, the participatory multicriteria approach provided a structured process for collective decision-making in an area where it has never been implemented.

Keywords Landscape planning · Stakeholder analysis · Evaluation of alternatives · Participatory multicriteria analysis · Yungas forest · Socio-ecological systems

Introduction

Forest loss and degradation are causing a decline in the quality of ecosystem services around the world (Campbell and others 2001; Maass and others 2005). It is increasingly recognized that fixing this problem takes more than just planting trees (Chazdon 2008; Rey Benayas and others 2009). Any intervention should aim at increasing the resilience of both the forest landscapes and the communities that they support (Pokharel and Nurse 2004; Brockington and others 2006; Sunderlin and others 2008). The Forest Landscape Restoration (FLR) approach has been promoted by IUCN and WWF International (Mansourian and others 2005) to meet the challenge of restoring the provision of goods and services in modified and degraded forest landscapes by explicitly integrating the concept of human well-being. FLR is described as a forward-looking approach that aims to strengthen the resilience of forest landscapes rather than to restore forests to their original state. Some key features of FLR are embodied in these definitions (see also FLR pillars listed in Annex I). Forest restoration has to be implemented at landscape level rather than at site level since it aims to restore ecological integrity as a whole. Replacing only a few attributes of forest functionality within a landscape may be inequitable (as it caters to only a limited number of stakeholders' requirements) and unsustainable (as it is more difficult to respond

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proactively to environmental, social and economic changes). Also, FLR enhances human well-being. The principle that ecological integrity and human well-being cannot be traded off against each other at a landscape level is referred to as the 'double filter' of FLR.

There is nothing radically new about any of these statements. As a matter of fact, while the overall conceptual framework of FLR is rather recent, virtually all the principles and techniques behind the approach are not new. The FLR approach draws heavily on, and brings together, a number of existing rural development, conservation and natural resource management principles (e.g. Turner and others 2001; Maginnis and Jackson 2005). In particular, the principles of FLR are consistent with a more general framework: the Ecosystem Approach (EA). The EA, which is articulated into 12 Principles (see Annex II), is the primary framework for action under the Convention on Biological Diversity (UNCED 1992), that defined it as a strategy for the integrated management of land, water and living resources. FLR and EA converge on three elements:

1. The ecosystem scale. The FLR should be implemented at a landscape scale, defined as a contiguous area, intermediate in size between an 'ecoregion' and a 'site', with a specific set of ecological, cultural and socioeconomic characteristics, distinct from those of the neighbouring areas (WWF 2004). According to the EA, ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems (Principle 3); the conservation of the ecosystem structure and functioning to maintain ecosystem services should be a priority target (Principle 5); the EA should be undertaken at the appropriate spatial and temporal scales (Principle 7).
2. People involvement. The FLR strengthens the idea that people who have a stake in the state of the landscape are more likely to engage positively in its restoration (Sheil and Liswanti 2006; Lynam and others 2007). An ecosystem-based approach sees the objectives of management of land, water and living resources as a matter of societal choice (Principle 1) and states that management should be decentralized to the lowest appropriate level (Principle 2). The EA considers all forms of relevant information, including scientific, indigenous and local knowledge, innovations and practices (Principle 11) and involves all relevant sectors of society and scientific disciplines (Principle 12).
3. Identification of alternatives. According to the FLR strategy, an integrated forest management is to be obtained through a suite of solutions, including improving the quality of existing forests. In general, four main (and not necessarily mutually exclusive) restoration strategies can be pursued: protection and natural recovery, management of natural regeneration, enrichment planting and direct plantation (Sarr and Puettmann 2008). The EA suggests that management must recognize that change is inevitable (Principle 9), and that an appropriate balance between, and integration of, conservation and use of biological diversity must be sought (Principle 10).

Several reports presented case studies illustrating successful implementation of FLR initiatives (Barrow and others 2002; Ecott 2002). While all these contributions argue that FLR and EA are conceptually interconnected and based on the same theoretical grounds, they do not explicitly structure FLR interventions in the frame of the EA; moreover, the methods adopted are presented only in general terms (Holl and others 2003). Also, while there is an increasing demand for active public involvement in decision-making, successful models for achieving this in FLR and EA practices have yet to emerge.

Concerning EA implementation, Shepherd (2004) proposed a five-step method, each step involving a range of actions. According to this author, the first step is based on three actions: determining the main stakeholders, defining the ecosystem area, and developing the relationship between them.

In this article we propose an application of these three actions to design a method consistent with the general principles of EA and FLR to select forest restoration priorities. The proposed method combines stakeholder analysis and participatory multicriteria analysis (MCA) to

Table 1 Framework for the implementation of a FLR strategy in the frame of the EA

Actions	Objective	Reference[a] (see Annexes 1 and 2)
Determining stakeholders	Identify all the stakeholders with interests in the "ecosystem"	1, 12; II, V
Defining the ecosystem area	Select between different alternatives an "ecosystem" where implementing restoration activities	7, 8, 11, 12; IV
Developing the relationship between them	Identify a mosaic of areas, managed by different stakeholders, at different intensities, within the overall ecosystem	10; III

[a] Arabic numbers refer to EA principles; roman numbers refer to FLR principles

implement the three actions presented in Table 1. The method was applied to a case study in the provinces of Salta and Jujuy, northern Argentina.

Framing the Method

In order to fulfil EA and FLR principles, a method for identifying forest restoration priorities must work at the ecosystem scale and must be capable to account for the multiplicity of legitimate values and aims in the society that confer complexity to ecosystem management. Indeed, the ecosystem is a constructivist concept where the observer plays a fundamental role; it is generated when an observer distinguishes differences in the observed world (Haag and Kaupenjohann 2001). There may be as many descriptions for a given (eco)system as groups of stakeholders, all of them equally legitimate and even occasionally incompatible.

Decision tools for environmental management have generally been used for modelling the preferences of the decision makers; this means that in order to select the "best" solution to a problem, decision makers usually defined the alternatives and the criteria of selection on the basis of their own perception of the problem. The social context in which ecological or environmental problems took place has been seldom considered, including the way in which such problems were perceived by local actors. Nowadays, it is widely recognized that these kinds of approaches are no longer reasonable (Margerum 2008; Francis and Goodman 2010). Contemporary problems are characterized by deep complexity: they are characterized by uncertain facts, values in dispute, high stakes and urgent decisions (Funtowicz and Ravetz 1994). In response to growing global environmental concerns (e.g. biodiversity loss, forest fragmentation, climate change, etc.), it has become evident that both the scale of analysis of the problems and the notion that the natural sciences are objective and value free have to be reviewed (Lackey 2001). Since real-world systems are multidimensional (and therefore complex) in nature, proper tools of analysis should be based on procedures that explicitly require the integration of a broad set of various, sometimes conflicting, points of view.

The term complex system has multiple meanings depending on its scope (e.g. Jørgensen and others 1992; Costanza and others 1993; Li and others 2004). In this work we use a "minimalist definition", i.e. we define a complex system as a system where at least one variable is not measurable and, in analogy with the complex numbers, the measure requires an "imaginary" component (Feoli and Zuccarello 1994). Variables measured by ordinal scales are examples of non-measurable variables, since the judgements such as "bigger than", "lower than" and "more important than" require using imagination or subjective judgement.

In order to openly incorporate stakeholders' values in decision making, multicriteria techniques are considered to be useful because they have the potential to explicitly take into account multidimensional, incommensurable and uncertain effects of decisions (Quaddus and Siddique 2001; van den Hove 2006). MCA deals with transparent choices between alternatives: it is a guiding tool used to choose among different options that are evaluated, ranked and weighted on the basis of different criteria. In particular, through MCA it is possible to account for the presence of different points of view by using weights and criteria that originate from values expressed by the actors involved in the decision (Gamboa 2006; Geneletti 2005, 2008). Consequently, in our study the combination of a stakeholder analysis, in order to identify actors and views, and a MCA, where we are able to represent and combine evaluation criteria belonging to different spheres, is in principle an appropriate approach.

The Case Context

The study region represents a dynamic socioecological system. From a geographical viewpoint, it spans over the provinces of Salta and Jujuy, northwestern Argentina, an area covered by the Yungas, an extensive system of native forests (Fig. 1). The Yungas region is an area of varied topography ranging from humid forest to misty pastures. Following the altitudinal gradient, forest is classified as premontane lowland seasonal forest, montane subtropical forest and upper temperate montane forest. Two other ecosystems continue further up the altitudinal zones: cloud grasslands and highland Andean grasslands. The Yungas are considered an international hot spot for biodiversity: it

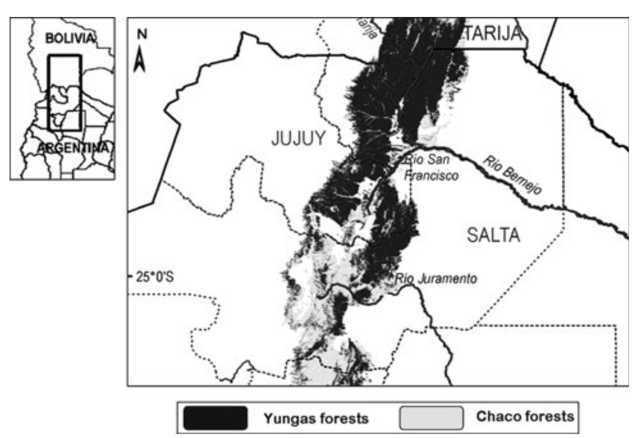

Fig. 1 The study area

is estimated that more than 230 tree species and 3,000 vascular plants are present in the region. The region encloses 60% of the country's bird species (Grau and Brown 2000). A portion of the Yungas Eco-region, 1,300,000 ha in Salta and Jujuy Provinces, was declared Biosphere Reserve of the UNESCO Man and Biosphere Reserve Program in 2002. In the previous four years, from 1998 to 2002, more than 194,000 ha had been deforested. Yungas mountain forests are relatively well preserved due to rugged topography that prevent extensive land clearing, even if unsustainable selective logging is an important degradation force. The conservation o the Yungas is mainly threatened by the expansion of the agricultural frontier. The introduction of the sugar cane plantations in the 1930s converted more than 170,000 ha of forest into cropland. Today, the expansion of the agriculture frontier is mainly driven by the soybean plantations (Grau and others 2005).

This territory of the Yungas in Argentina has been traditionally inhabited by the Kolla nation. The indigenous communities that live in the area rely on a subsistence economy based on transhumant cattle, and seasonal resettlement typical of the Kolla culture in the region. The economic situation in the area is difficult: most of the community members rely on occasional jobs or receive governmental subsidies. The youngest seasonally migrate to work in the vast plantations of the lowlands, and in the community there are no strong economic drivers that could change the economical setting at mid term. A more detailed description of the area can be found in Pacheco and others (2005) and Ianni and others (2010).

Actually, Yungas ecosystem is a mosaic of landscapes and rights. Land properties are organized in estates called *fincas* deriving from the Spanish land tenure system. The fincas generally span over wide areas at a watershed scale; they include the whole altitudinal range of ecosystems from the highland Andean grassland to the montane subtropical forest. Therefore, they are generally characterized by a landscape mosaic composed by protected areas, forest, agricultural lands, and areas devoted to cattle. Ecosystem management practices are currently not in place in the Yungas. The relationship between the communities and the landscape they inhabit is essentially a daily practice of decisions taken individually by the various social actors without a coordinated management plan or a common and shared set of rules to conform with.

The Case Study: Applying the Method in the Case Context

In order to implement the framework described in Table 1 in the study area, a stakeholder analysis was carried out to identify social actors and to involve them in selecting alternative areas and restoration interventions, in defining the criteria of evaluation, and eventually in selecting a priority area of intervention through MCA techniques.

The method is then presented in three stages:

1. Analysis of the social actors that have a stake in forest management in the study area;
2. Identification of feasible restoration actions and criteria to prioritise them;
3. Comparison and ranking of restoration actions on the basis of social actors' needs and expectations.

In this study, alternative restoration actions corresponded to potential alternative fincas where implementing FLR and criteria represented the relevant aspects to be taken into account during the prioritisation process.

Stakeholder Analysis

Stakeholder analysis is an approach for understanding a system by identifying the key actors or stakeholders and assessing their respective interest in that system (Grimble and Wellard 1997). Renard (2004) defines stakeholder analysis as a focused and well-planned exercise aimed at answering questions that are directly relevant and useful to the planning and management process. The objective of our stakeholder analysis was twofold: identifying all actors involved in forest use and management in the study area and describing the attitudes of potential practitioners and beneficiaries of the FLR. First, Yungas stakeholders were identified as the local actors that can affect or who are affected by the quality and quantity of services provided by the forest. Intact forests and woodlands provide a range of ecosystem services such as maintenance of water supply and quality, carbon sequestration, and a host of other benefits derived from biodiversity (Hein and others 2006). The selection process was done by researchers aided by local experts with vast experience and knowledge of the Yungas eco-social system. Through a "snowball method", stakeholders were also asked to identify other potential actors to involve. Then, the stakeholders' opinions were collected through semi-structured interviews, about one hour long, conducted by a researcher and a local expert who was a continuous link between the researcher and the stakeholders.

The data collected during the interviews was synthesized and represented in cognitive maps. A cognitive map links concepts to form chains and aims at disclosing individual perceptions of consequences and explanations associated with concepts (Eden and Ackermann 2004; Özesmi and Özesmi 2004). The cognitive maps were used as qualitative models of how our system (restoration in the Yungas) operates. The cognitive maps provided the answer to the following question: "what is, in your view and experience, forest restoration?"

Identification of Restoration Interventions and Evaluation Criteria

Stakeholders were asked to identify potential areas for forest restoration in the Northern Argentina Yungas ecosystem according to their expertise and actual priorities. Ten alternative fincas, equally suitable but differing in relation to objectives, values, and feasible restoration activities, were gathered at the end of the round of interviews.

A workshop was then organized to identify priorities. The fincas described by the stakeholders were presented to them as a list of alternatives; stakeholders were asked to suggest and discuss criteria to select the optimal finca for forest restoration from among the alternatives. Not all the interviewed stakeholders participated in the follow-up workshop. The ten stakeholders that attended the workshop represented five divergent perspectives on Yungas ecosystem management. Stakeholders represented different organizations and economic sectors working in the Yungas forests. The five perspectives represented at the meeting are defined as: economical (represented by the timber industry, TI), institutional (represented by the governmental agency for natural resources, GA), ecological (represented by environmental NGO, Env NGO), productive (represented by forestry consultants, FC) and spiritual (represented by the Aboriginal communities, AC). For ancestral cultures the forest has an intrinsic value as a reserve of life; for this reason we defined this vision as "spiritual". During the initial brainstorming session conducted by the researcher, more than 35 criteria were suggested. In order to fit in the requirements of a consistent set of criteria (i.e. exhaustive, coherent and non redundant), and to facilitate the measurement process, a review process was undertaken to eliminate and combine the initial set of criteria. Eventually, twenty criteria were selected and classified into four groups: biophysical, social, economic and political. The latter ones refer to criteria linked to the potentially wide political impact of a restoration action in terms of its visibility, possible replication and capability to withstand unpredictable changes.

Comparison and Priority Ranking

The purpose of this step was to derive a ranking of the alternative interventions. In MCA, the relative contribution of each criterion to the overall assessment of the alternatives can be expressed by assigning weights. To this purpose, we adopted the structured pairwise comparison method proposed by Sharifi and others (2004). This is a slight variation of the Analytic Hierarchy Process (AHP) developed by Saaty (1980), which offers the advantage of being easier to perform because participants are asked to rank criteria using a three-level scale, rather than the traditional seven-level scale. This means that each criterion can be equally important, slightly more important or strongly more important than the one that follows in the ranking. Given the mostly qualitative nature of the criteria and the varied fields of expertise of the assessors, we believe that this simplified approach was bound to provide results more consistent with the assessors' opinions. This method was applied both at group level (biophysical, social, economic and political), as well as to the different criteria within each group.

The scores were standardized with a linear function between 0 and the highest absolute score. Using the DEFINITE software (Janssen and others 2001), the comparisons of all pairs of effects were converted to quantitative weights for all effects. The ten options were evaluated from the perspectives of the stakeholders: for each stakeholder group the objective and subjective information were aggregated using the weighted linear combination. Lastly, sensitivity analysis was performed to assess the stability of results, their dependence on the set of weights expressed by the stakeholders and the similarity between alternatives. Weight sensitivity allows determining the set of weights that would cause changes in the rank order of a certain alternative (rank reversal).

At the end of the process we collected informal feedback from the stakeholders on their perceptions about the process.

Results

Stakeholder Analysis

Table 2 shows the stakeholder groups identified on the basis of the services provided by the native forests in the area. Figure 2 shows a sample cognitive map that draws the views of the stakeholder group "timber industry" (as defined in Table 2) which exploits the forest to get commercially viable timber. Similar maps have been drawn for all interviewed stakeholders. According to timber entrepreneurs, forests have no intrinsic value: the value of a forest exists as long as commercially viable valuable timber can be extracted. Native forest is seen as poor of valuable species; as a consequence, forest restoration is seen merely as forest enrichment.

The indigenous communities involved in the process rely on a subsistence economy: communities extract from the forest both timber products (wood for fuel and timber for constructions) and non-timber products (honey and bush meat), to complement the family economy. Wood (particularly around the village) is increasingly becoming a scarce forest resource. Forest restoration for them equals wood availability.

Table 2 Yungas stakeholders were identified as the local actors that had a stake in each of the ecosystem services provided by forest (production, regulation and cultural services)

Resource	Services	Related goods and services	Stakeholders
Native forest	Production	Fodder (including grass from pastures)	Local communities
		Fuel (including wood and dung)	Timber industry
		Medicinal resources	Forestry engineers
		Commercially viable timber	Economy consultants
		Genetic resources	
	Regulation	Gas regulation	Environmental agencies
		Climate regulation	Governmental agencies
		Disturbance prevention	
		Water supply and regulation	
		Soil formation and retention	
		Nutrient cycling	
		Pollination	
	Cultural	Habitat for wild plant and animal species	Community-based rural tourism operators
		Cultural, historical and religious heritage	
		Scientific and educational information	
		Opportunities for recreation and tourism	

Stakeholders represent different organizations and economic sectors working in the Yungas forests. [The list of ecosystem services of the native forest in the study area is based upon Millennium Ecosystem Assessment (2003) and Hein and others (2006)]

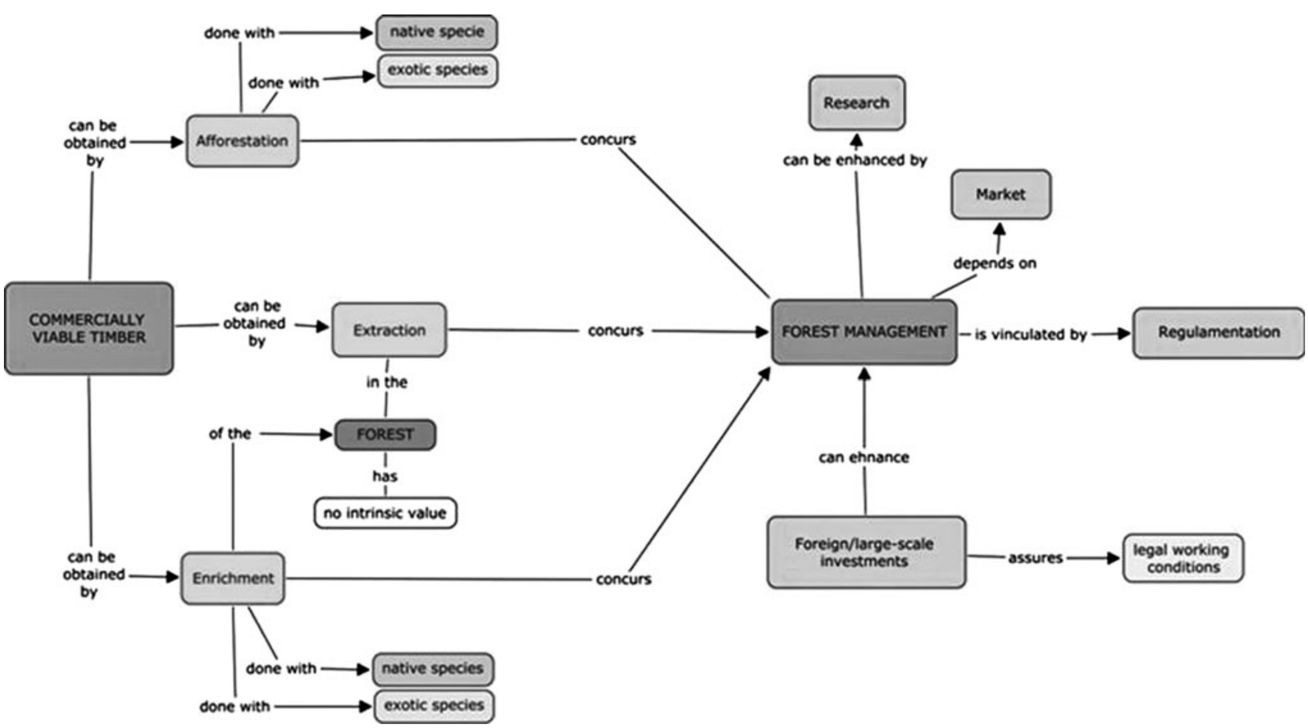

Fig. 2 Cognitive map of the views of the stakeholder group "timber industry"

The workshop confirmed the different perspectives that emerged during the interviews: timber industry and forestry consultants were mainly concerned with forest production. In particular, they greatly supported forest plantations of exotic species that grow faster than native species. The coordinator of the regional office of natural resources of Salta region participated in the meeting with the concern for the Yungas to preserve providing goods and services and with the concern that the restoration action can be seen by the population as an output of a political choice. Biologists with vast working experience on the Yungas ecosystem from the local environmental NGO were focussing on the deforestation patterns due to the conversion of forest to soybean and the unsustainable rates of exploitation of the Yungas. Indigenous communities' vision was represented by a sociologist supporting

community-based rural tourism and by the coordinator of the regional office for indigenous rights. They were mainly concerned with all aspects associated with the respect of cultural and traditional values of the forest.

Restoration Alternatives and Evaluation Criteria

The proposed alternative fincas in Jujuy and Salta regions differed in relation to management, land use, land tenure, and size.

Finca Yaquy, Finca Los Naranjos and Finca Vinalito are vast indigenous territories; the communities rely on a subsistence economy based on transhumant cattle and on agriculture. Ledesma is an agro-industry that cultivates about 35,000 ha of sugar cane plantations and about 2,000 ha of citrus fruits. Within the finca there are fragments of forest in a very good state of conservation. In the region soybean cultivation has grown in the last years and ecological corridors have almost completely been destroyed by aerial dispersion of pesticides. An alternative FLR option to restore the barriers has been proposed. Finca Chalican and Finca Acambuco are administrated by the State; in particular Finca Acambuco is a regional ecological reserve. Finca Fontanelas, Finca Rio Seco, Finca El Pongo belong to private forestry companies.

Table 3 presents the criteria and the measurement units that were decided in the meeting. The assessment of the alternatives was qualitative (e.g. ++, −), quantitative (e.g. km, pesos/ha) or binary (Y/N), according to data availability. Quantitative criteria were classified as 'benefit' (B, i.e., the higher the value, the more suitable the option) or 'cost' (C, i.e., the lower the value, the more suitable the option).

Comparison and Priority Ranking

The effects table (Table 4) summarizes alternatives and evaluation criteria. Table 5 presents the weights assigned by the stakeholders to the twenty sustainability criteria and the four groups used in the Yungas study area. Figure 3 depicts the derived ranking of the alternatives according to the five perspectives. On the basis of the weights assigned by the stakeholders the Ledesma was the preferred alternative followed by Los Naranjos and Rio Seco. The sensibility analysis showed robust ranking and no rank reversal in almost all cases: this confirmed the superiority of the Ledesma option to the others.

In particular, the Ledesma finca appeared to be the preferred option due to the performance within the context of the environmental and social criteria. Table 5 shows that although different groups of stakeholders diverged on the importance of the criteria, they all agreed upon the dominance of the "social" criteria group. The high weight assigned by the stakeholders to the criteria that describe the level of organization (as a benefit), the level of conflict (as a cost) and engagement (as a benefit) concurred to the high performance of Ledesma agro industry in the social realm. This derives from the fact that in Ledesma, as in every industry, decision making is evidently hierarchical and it follows a command and control approach. In this way, conflicts among opposite views are obviously minimized by absence of information and consultation. On the other hand, decisions and the degree of engagement are ruled by contracts and are lead by one or a limited numbers of persons; this maximises the probability of the continuation of a project over time, once implemented. Also in the environmental criteria, the Ledesma finca ranked first. As a matter of fact, the finca spans over wide areas, it borders Calilegua national park and the Yungas biosphere reserve; the soil is fertile and there is water availability. Hence, restoration interventions according to stakeholders' criteria are expected to be successful.

The public MCA process worked effectively and was completed in four hours. Stakeholder comments supported the explicit structuring of the decision process and the avoidance of seeking consensus as the end-goal was particularly appreciated. Nevertheless, the MCA logic was very unfamiliar to some of the participants and misunderstandings frequently occurred during the process. At the end of the workshops the comments recorded were sceptical about the real applicability of the tool as a regular support to decision making.

Discussion and Conclusion

The discussion focuses on three main topics: the effectiveness of the proposed method in implementing the FLR principles in the framework of EA; the need to incorporate the idea that interactions between society and nature are perceived and understood differently by different social actors into any restoration activity; and the usefulness of multicriteria methods in involving stakeholders and structuring the decision problem.

The proposed method accounted for the main principles of FLR approach and EA described in section 1: acting at ecosystem scale, involving stakeholders, and considering alternatives. Its application represented the first attempt to apply EA principles to forest restoration at landscape scale in the Yungas region. The benefits obtained by the application of the method were twofold. First, researchers and local actors were forced to conceive the Yungas as an ecosystem, as a complex net of actors and rights rather than as a sum of personal interests. Stakeholders that live in the same environment do not know each other and each of them makes decisions on their own that affect the Yungas

Table 3 The criteria selected by the stakeholders

Criterion	Unit	Scale	Description
Bio-physical			
Forest recruitment (C)	Number of plants		Number of new plants per hectare (indirect estimation of the good health of the forest)
Degradation trend		–, ++	Evolution of the forest in absence of any intervention
Biodiversity		0, +++	Intrinsic value of the site concerning biodiversity
Ecological values		–, +++	Ecological features of the landscape that can concur to achieve a successful result
Soil conservation		0, +++	Additional benefit: capability of afforestation/ enrichment to preserve or recuperate the soil
Water availability (B)	mm		Measure of the quantity of rain
Social			
Organization		0, +++	Measure of the organization and of the flow of information (decision) in the community/company
Concern for the forest		–, +++	Spiritual value for a community or a concern of a private entrepreneur
Expertise in plantations (B)	Years		Years the community/company has been involved in forestry activities
Availability of persons (B)	Number of persons		Number of persons that would actively be involved in the project
Engagement		0, +++	Level of interest demonstrated by the community/company for the restoration project
Conflict		0, +++	Level of conflict in the community/company that could affect the successful implementation of the project
Juridical security		0, +++	Land tenure
Economic			
Logistic facilities (C)	km		Distance from logistic headquarters
Operational cost (C)	Pesos/ha		Cost of the facilities
Beneficiaries (B)	Number of persons		Number of persons that could benefit from the project (i.e. families of the workers)
Land use change (C)	%		Probability the community/private company change land use in the future
Political			
Visibility		0, +++	Degree of exposure to public notice
Replication (B)	Yes/no		Possibility for the community/company to replicate the project
Resilience		–, +++	Capability to cope with unexpected events (instability, unpredictable changes, etc.)

The middle columns present the units of measure of the quantitative criteria values (unit) and the minimum/maximum range (scale) of the qualitative scale criteria values

and the other components of the system. They were forced to comply with the overall long-term objective, i.e. the conservation of the Yungas, and to accept alternative ways for achieving it. A second benefit was that MCA served as a tool for social learning since actors were forced to work together, and more, to structure an explicit approach to evaluation. The participatory multicriteria approach provided a simple tool for structured and logical decision making; this can encourage a change in the methods for ecosystem management for the area of Yungas.

In the last decades, the focus of forest management has gradually widened from sustained yield timber to sustainable forest ecosystem management. This has occurred on the basis of the recognition of multiple forest values beyond timber values, such as the value of non-timber products and ecosystem services (García-Fernández and others 2008). Forest management has also changed from 'management by exclusion' to 'management by inclusion' recognizing the need to incorporate the preferences of multiple stakeholder groups, such as local communities, environmental groups, forest industries, and aboriginal groups into forest management decision making (Purnomo and others 2005; Sheppard and Meitner 2005). We used a stakeholder analysis to understand the interests at stake in the Yungas ecosystem and we drew simple cognitive maps describing the attitudes of potential practitioners and

Table 4 The effects table summarises alternatives and evaluation criteria

	Yacuy	Chalicán	Los Naranjos	Ledesma	Acambuco	Barriers	El Pongo	Vinalito	Rio Seco	Fontanela
Bio-physical criteria										
Forest recruitment	0	0	100	20	30	0	0	30	100	100
Degradation trend	−	−	+	+	−	−	−	−	++	+
Biodiversity	+	+	++	+	++	0	+	++	++	+
Ecological values	+	+	+++	++	++	++	−	−	+	+
Soil conservation	+	+	0	++	+	++	++	++	0	0
Water availability	900	800	1,000	1,000	800	900	800	600	900	850
Social criteria										
Organization	++	++	+++	+++	+	+	+	+	++	+
Concern for the forest	++	+	+++	−	++	−	−	++	+	+
Expertise in plantations	3	0	8	40	0	0	3	0	10	25
Availability persons	5	10	10	10	5	3	10	5	5	3
Engagement	+	+	+	++	+	++	+	+	++	++
Conflict	+	+	+	0	++	0	+	+	0	0
Juridical security	+++	+++	+++	+++	++	+	+++	++	+++	++
Economic criteria										
Logistic facilities	140	80	30	115	200	50	30	170	120	165
Operational cost	3,000	1,500	2,400	700	3,000	700	3,000	3,000	700	700
Beneficiaries	25	50	50	1	25	1	0	25	1	1
Land use change	20	40	20	10	60	10	60	20	10	50
Political criteria										
Visibility	+	++	+	+	++	+	+	++	0	+
Replication	No	No	No	Yes	Yes	Yes	No	No	Yes	Yes
Resilience	60	70	70	90	70	80	70	50	70	70

The assessment of the alternatives was qualitative (e.g. ++, −), quantitative (e.g. km, pesos/ha) or binary (Y/N), according to data availability. Quantitative criteria were classified as 'benefit' (B, i.e., the higher the value, the more suitable the option) or 'cost' (C, i.e., the lower the value, the more suitable the option)

beneficiaries of FLR. Delgado and others (2009) presents a review of methods for participatory modelling. Participatory modelling encourages social learning about the ecological system using systems diagrams as the main tool. These diagrams facilitate an understanding of the dynamics and complexity of social-ecological systems, allow a graphical visualization of the potential effects of human actions within a system, and facilitate the identification of the use of ecosystem services by social actors and highlight differences in values. In our case the maps were used in particular with this latter purpose; the maps helped providing an in-depth knowledge of the problem, and in understanding attitudes of the social actors towards restoration. The maps showed that the different social actors involved in the Yungas management have strongly differing views about forest use and value. This was also explicitly reflected in the MCA: for example, in full agreement with the views expressed through the cognitive maps, the weights assigned to the criterion "concern for the forest" (Table 5) by the timber industry point of view are remarkably low (while those of the aboriginal communities are very high). Actually, when deciding to implement a restoration project, it is not trivial to pose the question: what is forest restoration and what are its specific purposes in this context? This is very relevant to the intervention since, as stated by the key principles of FLR, an integrated forest management involves a suite of possible solutions.

The forest is a mosaic of stakes and actors and forest management deals with the challenge of reconciling objectives: producing timber, extracting firewood and maintaining ecological sustainability. Unexpectedly, in the MCA analysis all the actors, notwithstanding their different views, assigned high weights to the social dimension of the problem. In particular very high weights were assigned to the parameter "engagement".

The usefulness of multicriteria methods in involving stakeholders has already been widely proved (Martin and others 2000; Kangas and Kangas 2005). Generally, one of the key attractions of MCA techniques is the transparency of the decision process and results. In theory, the core of

Table 5 "Stakeholder group" weights for the 20 sustainability criteria used in the Yungas study area

CBio-physicalriterion	Weights of the stakeholder groups									
	TI		GA		Env NGO		FC		AC	
Biophysical	0.231		0.157		0.273		0.273		0.157	
Forest recruitment		0.052		0.097		0.047		0.096		0.079
Degradation trend		0.321		0.193		0.164		0.191		0.058
Biodiversity		0.227		0.327		0.219		0.261		0.197
Ecological values		0.104		0.057		0.425		0.324		0.308
Soil conservation		0.168		0.074		0.082		0.074		0.102
Water availability		0.129		0.252		0.063		0.054		0.256
Social	0.459		0.409		0.356		0.356		0.409	
Organization		0.139		0.323		0.245		0.181		0.285
Concern for the forest		0.08		0.024		0.031		0.028		0.076
Expertise in plantations		0.031		0.052		0.075		0.036		0.058
Availability of persons		0.042		0.255		0.129		0.072		0.15
Engagement		0.34		0.203		0.295		0.241		0.361
Conflict		0.263		0.104		0.038		0.142		0.045
Juridical security		0.104		0.041		0.187		0.299		0.027
Economic	0.176		0.314		0.21		0.21		0.121	
Logistic facilities		0.23		0.377		0.23		0.176		0.185
Operational cost		0.176		0.289		0.176		0.23		0.241
Beneficiaries		0.135		0.111		0.135		0.135		0.093
Land use change		0.459		0.222		0.459		0.459		0.481
Political	0.135		0.121		0.161		0.161		0.314	
Visibility		0.265		0.204		0.204		0.265		0.464
Replication		0.204		0.265		0.265		0.204		0.179
Resilience		0.531		0.531		0.531		0.531		0.357

Stakeholder groups were: *TI* timber industry; *GA* governmental agency; *Env NGO* environmental NGO; *FC* forestry consultants; *AC* aboriginal community. The first column shows the relative weights of the group level (biophysical, social, economic and political), the second column shows the weights of the different criteria within each group

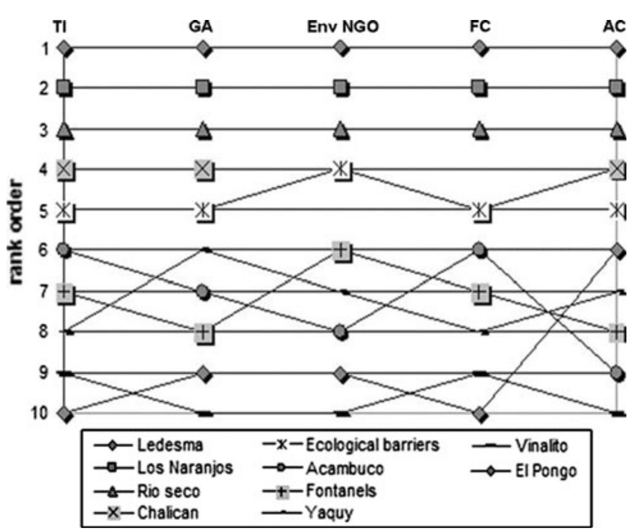

Fig. 3 Ranking of the alternatives according to stakeholders perspectives

MCA lies in the participation of different actors: the more different background and social positions participants have, the more successful the approach. However, MCA is run by people: we should be fully aware that people's values and beliefs heavily condition the analysis. Ananda and Herath (2003) examined the feasibility of the AHP in incorporating stakeholder preferences into the Australian regional forest programme. They concluded that simplifying preference structures can eliminate hidden ambiguities and criteria so that everybody is able to understand the mechanics of the process, which in turn increases the credibility. Indeed, in this study MCA served as a forum for discussion, negotiation, exchange of knowledge and finally selection of a finca that was closest to the economic, social, environmental and political goals, as seen by the relevant actors involved in the decision. The public MCA process worked well and was favourably supported by various stakeholder comments: the avoidance of seeking

consensus as the end-goal seemed consistent with stakeholders' expectations. Nevertheless, in our case considerable scepticism about real impact of the method on concrete decisions and actions remained evident among the stakeholders. The MCA logic was very unfamiliar to some of the participants and misunderstandings occurred. Additional misunderstandings occurred because of time constraints. Time was a limiting factor inhibiting people with different capabilities and expertise from becoming familiar with the process. Sufficient time must be allocated to MCA so that people with different skills and expertise can familiarise themselves with it and understand its actual contribution to decision making: it is a tool to improve the process, rather than to provide the solution. Hence, the challenge of participatory multicriteria methods is that participants must see the MCA analysis as a framework aiding and simulating the real choice process, not as a mathematical exercise.

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Annex 1

Forest Landscape Restoration principles, as described by Mansourian and others (2005) are synthesized hereafter:

I. It is implemented at a landscape scale. Planning for forest restoration is done in the context of other elements: social, economic, and biological in the landscape.
II. It has a socioeconomic dimension. It is argued that people who have a stake in the state of the landscape are more likely to engage positively in its restoration.
III. It addresses the root causes of forest loss and degradation.
IV. It opts for a package of solutions, including improving the quality of existing forests.
V. It involves a range of stakeholders in planning and decision making to achieve a solution that is acceptable.
VI. It involves identifying and negotiating trade-offs.
VII. It places the emphasis not only on forest quantity but also on forest quality.
VIII. It aims to restore a range of forest goods, services, and processes, rather than forest cover per se.

Annex 2

The EA principles:

Principle 1: The objectives of management of land, water and living resources are a matter of societal choice.
Principle 2: Management should be decentralized to the lowest appropriate level.
Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

(a) Reduce those market distortions that adversely affect biological diversity;
(b) Align incentives to promote biodiversity conservation and sustainable use;
(c) Internalize costs and benefits in the given ecosystem to the extent feasible.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the EA.
Principle 6: Ecosystems must be managed within the limits of their functioning.
Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
Principle 9: Management must recognize that change is inevitable.
Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

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